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OPERATION EVEREST II ALTITUDE DECOMPRESSION SICKNESS  
DURING REPEATED ALTI. (U) ARMY RESEARCH INST OF  
ENVIRONMENTAL MEDICINE NATICK MA M K MALCONIAM ET AL.  
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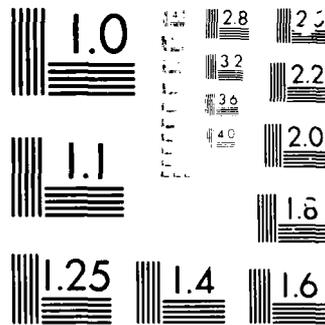
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## ABSTRACT

The incidence of altitude decompression sickness (ADS) was studied in 23 altitude scientists during repeated altitude exposure to 15-20,000 feet in a decompression chamber. Prior to each altitude exposure, a 30-60 minute prebreathing period with 100 % oxygen took place. Ascent was made to a altitude at a rate of 2000 feet per minute. The altitudes studied ranged from 15-29,000 feet. Symptoms reported appear consistent with previous reports with regard to severity of symptoms. Incidence of ADS at 26-29,000 feet was 29.7%, during 274 chamber flights and 1264.6 hrs of altitude time. Incidence appeared related to frequency of exposure, severity of altitude and physical activity. Incidence was not related to age or body index (weight/height<sup>2</sup>). This high incidence of ADS reported in this study is similar to that reported by NASA.

Key Words: Bends, Altitude, Hypobaric Chamber

## INTRODUCTION

Altitude Decompression Sickness (ADS) is a well-recognized and serious consequence of exposure to hypobaric conditions. It has been described during and after aircraft as well as hypobaric chamber flights. The overall incidence of this illness has been estimated to be about two percent of all flights (3-6,11,14,16,20,21,24) and is said to be directly related to altitude, age, frequency of exposure, physical activity at altitude and, possibly, obesity (1,8,18,21,22). An unusually high incidence of ADS was noted in investigators during a recent study of chronic progressive hypoxia in a hypobaric chamber entitled Operation Everest II. The observations are reported here to illustrate that ADS can be a factor at relatively low altitudes even when preventative measures are taken.

## METHODS

Operation Everest II was a 40-day decompression chamber study of eight subjects simulating a climb of Mt. Everest (29,000 ft, inspired partial pressure of oxygen 42 mmHg). The details of that study will be presented elsewhere (Houston, IN PREP). During the study, there were a total of 24 investigators making frequent chamber flights to monitor subjects and conduct experiments. The investigators ranged in age from 23 to 72 years, were in apparently good health, and had passed a screening physical exam equivalent to the U.S. Army Class III Flight Physical. The majority were very knowledgeable in altitude medicine and many had previous hypobaric chamber experience.

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CPT. Mark K. Malconian is a Flight Surgeon and Anesthesiologist serving as a research medical officer with the Altitude Research Division of the U.S. Army Research Institute of Environmental Medicine, Natick, MA.

The ascent rate on all flights was 2000 ft per minute or less. In an effort to prevent altitude decompression sickness, investigators prebreathed 100% oxygen for 30 minutes for flights between 15-25000 feet and for one hour prior to all chamber flights to altitudes greater than 25,000 ft. Scott aviation masks (Model #28314) were used for prebreathing on flights under 25,000 feet. U.S. Air Force standard aviator's masks (MBU 5/P) were used for prebreathing on flights to 25,000 feet and above. Because they were more comfortable and less cumbersome, Scott masks were generally worn within the chamber once the investigators reached altitude; however, the Air Force masks with microphones were often used at the higher altitudes to facilitate communication.

All investigators were briefed on ADS symptoms prior to their initial flight and were required to report any symptoms to the flight surgeon on duty. Each was questioned in detail as to the onset, nature and duration of reported symptoms and their responses were recorded.

Student's t-tests were used to compare the mean ages, body indices, and altitude time between the investigators who experienced ADS symptoms and those who did not. A chi square was used to compare the total number of flights between the two groups. A P value at 0.05 or less was accepted as significant.

## RESULTS

A total of 332 flights were made during this study with 1455.7 hours of cumulative altitude time. There were 275 flights over 15,000 feet with 1264.1 hours altitude time. Altitude decompression sickness ADS symptoms and flight histories were recorded for all investigators involved in flights above 15,000 feet. No symptoms of ADS were reported under 15,000 ft.

Sixteen individuals had a total of 28 episodes of ADS manifested by a total of 37 symptoms (figure 1): 23 symptoms of joint pain, 6 of vertigo, 4 of scotoma, 2 instances of skin lesions, and 2 reports of disorientation. The onset of symptoms in all but 2 cases occurred within three hours after arriving at altitude. The other two cases occurred immediately upon return to sea level and were manifested by scintillating scotoma. Most symptoms resolved rapidly with return to sea level, however, one episode of joint pain resolved after two hours at sea level and one case of skin symptoms persisted for one hour at sea level.

Table 1 compares the mean age, body index, flight count and total altitude time of the 16 investigators who had symptoms of ADS and the 7 who did not. There were no significant differences in age and body index between the two groups. The group with ADS had participated in more flights above 15,000 feet than the group without ADS but this difference was not significant. There was a significant difference in total altitude time between the two groups. The group with ADS had logged more than twice the altitude time above 15,000 feet than the group without ( $66.13 \text{ hours} \pm 12.9$  vs.  $28.82 \pm \text{hours } 8.8$ ,  $p < 0.05$ ). Table 2 shows the occurrence of symptoms by altitude and number of exposures. Not all the categories in the table are represented because there were no investigators who had 31-40 flights at altitudes between 15-20,000 feet. From the data it is seen the overall incidence of ADS as well as the ADS incidence per person increased with increasing altitude.

## DISCUSSION

Each investigator was knowledgeable about ADS and was experienced in altitude medicine. All cases of ADS were documented and verified by two flight

surgeons. Although the incidence of ADS reported here is high, the data are believed reliable. Careful records of altitude exposure of each investigator were maintained.

The distribution of the frequency of types of symptoms appear consistent with previous reports, i.e. joint pain being the most common and in most cases benign. Neurological symptoms (which are the most serious manifestations) and skin symptoms occurred slightly more frequently than in previous reports (6,12).

It is clear that the incidence of ADS from this study (2.7% at 15-20,000 ft., 14.6% at 21-25,000 ft., 29.7% at 26-29,000 ft.) is much higher than the 0.5 to 2% reported in routine hypobaric chamber training for U.S. military aviators (16,24). This apparently high incidence cannot be explained on the basis of age or obesity, for there were no significant differences in these factors between those who experienced symptoms and those who did not. The incidence was directly related to both altitude achieved and total time at altitude. However, the occurrence of symptoms at the lower altitudes (under 20,000 ft) is not consistent with previous reports.

Although the incidence of ADS in this study is higher than in most previous reports, the data from this study is consistent with studies of ADS in hypobaric chambers by NASA. NASA reports an incidence of ADS at 29,000 feet of approximately 30% (even with prolonged denitrogenation protocols), which compares favorably with the incidence reported here (29.7% at 26-29,000 feet). One explanation for this disparity may be related to physical activity and exercise at altitude. In military aviation training chamber flights and during actual flying in hypobaric environments, aviators do very little physical activity. In contrast, during Operation Everest II and the NASA studies, a significant amount of exercise and physical activity was performed at altitude. Physical

activity may also explain the higher incidence of ADS in hypobaric chamber instructors than in student pilots. Instructors move around significantly more than the students.

Another explanation for the high incidence of ADS in this and the NASA study concerns reporting of symptoms. During these studies reporting of symptoms was encouraged, to include minor joint pain. In the operational aviation medical environment, the threat of potential grounding discourages aviators from reporting minor symptoms.

In summary, this study demonstrated a very high incidence of ADS that was not related to age or body index, but appeared to be related to repeated altitude exposures and the degree of altitude. Individuals going to altitude in a hypobaric chamber, where physical activity will be performed may show a high incidence of ADS if carefully monitored for symptoms of ADS.

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The views, opinions, and/or findings contained in this report are those of the authors and should not be construed as an official Department of the Army position, policy, or decision, unless so designated by other official documentation.

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Table 1 - COMPARISON OF PROFILES IN INVESTIGATORS WITH AND WITHOUT ADS

	<u>N</u>	EXPOSURE (number)	ALT. TIME (hrs)	AGE (years)	BI (kg/m <sup>2</sup> )
INVESTIGATORS WITH ADS	16	12.4 ± 2.5	66.13 ± 12.9	40.6 ± 3.1	24.33 ± .04
INVESTIGATORS WITHOUT ADS	7	7.00 ± 1.6	28.82 ± 8.79	42.7 ± 12.5	24.79 ± 1.25

ADS = altitude decompression sickness. Values are means ± s.e.m. Exposure represents mean number of altitude flights, Alt. Time is mean individual total altitude time. BI is body index (weight/height<sup>2</sup>). N2 number of investigators.

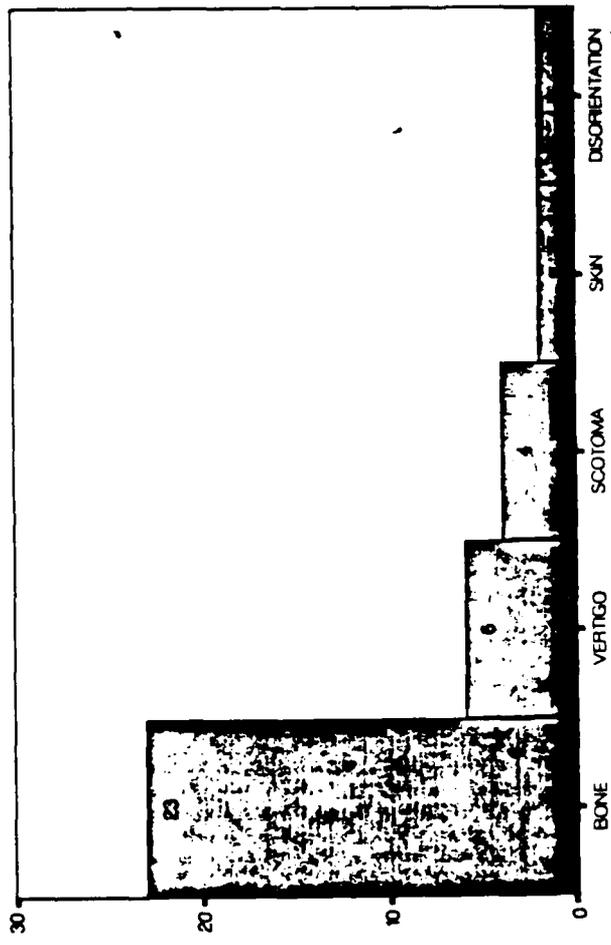
Table 2 - Altitude Decompression Sickness (ADS) by Altitude and Exposure

EXPOSURE Number	ALTITUDE (ft)							
	15-20,000		21-25,000		26-29,000		15-29,000	
	SX/FLS	I with SX/I	SX/FLS	I with SX/I	SX/FLS	I with SX/I	SX/FLS	I with SX/I
0-10 incidence	3/120 2.5%	2/22 14.3%	8/37 21.6%	6/15 40%	5/11 45.4%	4/4 100%	16/168 9.5%	11/22 50%
11-20 incidence	0/26 0%	0/4 0%	2/23 87%	2/6 33%	0/9 0%	0/4 0%	2/58 3.4%	2/9 22.2%
21-30 incidence	1/2 50%	1/1 100%	3/23 13%	2/3 66%	2/10 20%	2/4 50%	6/35 17%	4/5 80%
31-40 incidence	-	-	0/6 0%	0/1 0%	4/7 57.1%	2/2 100%	4/13 30.7%	2/2 100%
0-40 incidence	4/146 2.7%	3/22 13.6%	13/89 14.6%	10/20 50%	11/37 29.7%	8/11 72.7%	-	-

SX=SYMPTOMS  
 FLS=FLIGHTS  
 I=INVESTIGATORS  
 TOTAL FLIGHTS: 274  
 TOTAL CASES ADS: 28  
 TOTAL SYMPTOMS: 37  
 NUMBER OF PEOPLE WITH SX: 16  
 NUMBER OF INVESTIGATORS: 23  
 TOTAL FLIGHT HOURS: 1264.6

Exposures represent the sequential number of flights. Thus, for 0-10 exposures at 15-20,000 feet, there were 120 flights on which there were 3 cases of ADS, and there were 22 people in this category of which 2 had ADS.

FIGURE 1 - DISTRIBUTION OF SYMPTOMS. There were a total of 28 cases of ADS with 37 symptoms reported by 16 individuals.



**DISTRIBUTION OF SYMPTOMS**

FIGURE 1 - DISTRIBUTION of SYMPTOMS. There were a total of 38 cases of AIDS with 37 symptoms represented, by 16 individuals.

END

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